Liquid ^{3}He in Random Media

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Liquid ^{3}He is the purest form of matter in the universe. Any impurity, even the isotope ^{4}He is expelled by the large zero-point pressure of the fluid. The discovery that liquid ^{3}He could be infused into ultra-low density glass - silica aerogel - and exhibited superfluidity even under confinement in this complex material was profound. Silica aerogel is a network of strands and clusters of SiO_2 that is mostly empty space. This *gossamer* structure is a *random fractal* - a structure with no long-range order, but power-law scaling of the density correlation function over several decades of spatial scales. I illustrate these properties with simulations of the growth of silica aerogels and describe the structure and some of the ideas proposed that make these complex structures of interest for investigating the effects of disorder, spatial confinement and correlations on the ordered phases of a superfluid ^{3}He. I discuss recent advances based on the fabrication of *anisotropic* of silica aerogels with exceptional homogeneity. Liquid ^{3}He infused into anisotropic aerogels provides new insights into the nature of unconventional pairing in disordered anisotropic media. I report theoretical predictions and analysis for the phases of superfluid ^{3}He infused into homogeneous *uniaxial* uniaxial "stretched" and "compressed" aerogels. I present a theory that incorporates the effects of both local and global anisotropy on the phase diagram and NMR signatures of superfluid ^{3}He in anisotropic aeorgels. In this model random anisotropy originates from mesoscopic structures in silica aerogels. This random field model is coarse-grained on the atomic scale, and formulated in terms of local anisotropy in the scattering of quasiparticles in an aerogel with orientational correlations. Long-range orientational order of anisotropic scattering centers is related to the phases observed in globally anisotropic aerogels.
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